CHAPTER 1 Matter around us

1.1 Introduction

Chemistry is about what matter is like and how it behaves, and our explanations of its behavior.

What is matter? This word is used to cover all the substance and materials from which the physical universe is composed of.

In chemistry we investigate,

(i) What changes take place in these materials, how do these changes occur and what can be done to carry out these changes?

(ii) Why do these materials exist?

If we look around us then there are number of things in which, **matter** is displayed, with following particulars, prominently.

1. The matter has mass

If we take two pieces of bricks of different size, we will find that one is lighter while the other is heavy. The small sized brick is lighter because it contains less matter, while big sized brick is heavier because it contains more matter. Hence, the amount of matter present in anything is called its mass.

The things may be invisible even then they will have some mass e.g., the air. Although air is invisible even then it has some mass.

2. The matter occupies space

You must have experienced this phenomenon during your everyday life. If one stool is placed in the corner of your drawing room, you know another stool cannot be placed in the same corner. If the space on your bookshelf is completely filled with the books, you cannot keep more books on it. The two trucks coming from the opposite directions in a narrow lane cannot cross each other as there is space only for one. If they will try to cross each other they will collide. Therefore, it is clear that matter occupies space.

3. The matter has inertia

If anything is lying on any place, it will remain there until and unless some external force disturbs its position. Similarly if anything is in motion, it will remain in motion till some external force stops it. This is known as property of inertia. The matter itself cannot change its position. Suppose if a football is placed in the centre of a playground, it will remain there till it is pushed by anybody. Similarly if the football is pushed by a player it will move on till it is stopped by other players or by the friction of the play-ground.

4. The matter is effected by the gravity

If anything is thrown upward with a certain force it will automatically come to the ground because of force of attraction exerted by the earth. This attraction is called gravity.

When you throw a ball upward with a certain force, it will automatically come down on the earth because of earth's gravity.

The fruits always fall downwards from the trees because of this gravity. Similarly water always flows from higher level to lower level.

5. The matter cannot be destroyed

In all physical and chemical changes, total mass of the matter before and after the change remains the same. This can be proved by a simple experiment performed by Lavoisier.

Lavoisier's experiment - Lavoisier took tin metal in an airtight flask. The flask (with tin) was weighed. It was then heated. Tin metal reacted with the oxygen present in the air of the flask and was converted into tin oxide. The flask was cooled and again weighed. It was found that the weight practically remains unchanged.

Things that exist around us but do not have any mass or occupy space are not considered as matter. For example, we do not consider heat or light or sound or electricity or even our shadow as matter for the simple reason that they do not have mass or occupy space. So how would you know what is matter and what is not matter? Find out if it has weight. If it does not have weight then it is not matter.

1.2 Composition of matter

Matter is categorized into two broad classes :

(i) Living : Matter which is obtained from living organisms.

(ii) Non-living : Matter which is obtained from non-living things.

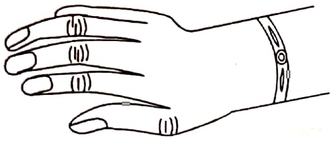


Fig. 1 Living hand with non-living band.

Each of these is further classified into:

(a) **Element**, substance that cannot be made simpler by chemical means.

(b) **Compound**, substance formed by the chemical combination of two or more elements.

(c) **Mixture**, substance formed by mixing of two or more elements or compounds.

All matter is composed of extremely tiny particles called atoms, molecules and ions. The atom is the smallest particle of an element that can take part in a chemical reaction. It may or may not exist in a free state. There are more than 118 kinds of elements known to man. Most of these elements are incapable of existing independently.

The atom or a group of atoms that is capable of independent existence is called a molecule.

For example, if a grain of sugar is divided into two and then further divided and this process is repeated many times, then the tiniest particle which has the properties of sugar is known to be the molecule of sugar.

The molecules of a particular substance are all alike.

In order to understand it just pursue the activity described below.

ACTIVITY.1.1

Take sugar in different quantity in four different dishes (5gm, 2gm, 1gm and 0.5 gm) and four different beakers (A, B, C, D) each having 10 ml of water. Now dissolve the sugar in these beakers. Now taste each beaker, you will find that taste in each beaker will be sweet.

Inference is that nature of sugar is giving a sweet taste to water and the quantity does not have any impact on it though sweetness will be different.

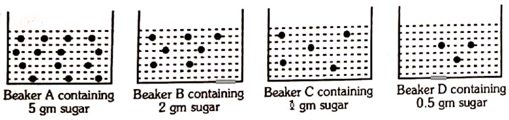

Beaker A containing 5 gm sugar
Beaker B containing 2 gm sugar
Beaker C containing 1 gm sugar
Beaker D containing 0.5 gm sugar

Fig. 2

1.3 Materials

The word 'material' is used to describe any kind of matter. It is further classified into two types.

(a) Homogeneous material

A homogeneous material (from the Greek word 'homo' means same) has the same composition and properties throughout.

Examples of homogeneous matter in elements: Silver, gold, wood, aluminium etc.

Examples of homogeneous matter in compounds: Sugar, alcohol, water, glycerine.

(b) Heterogeneous material

A heterogeneous material (the word 'hetero' means different) has different properties, in different parts and is not uniform.

Example of heterogeneous matter: soil, rocks, sand etc.

Matter may exist in any of the three physical forms.

(i) Solid (ii) Liquid (iii) Gas

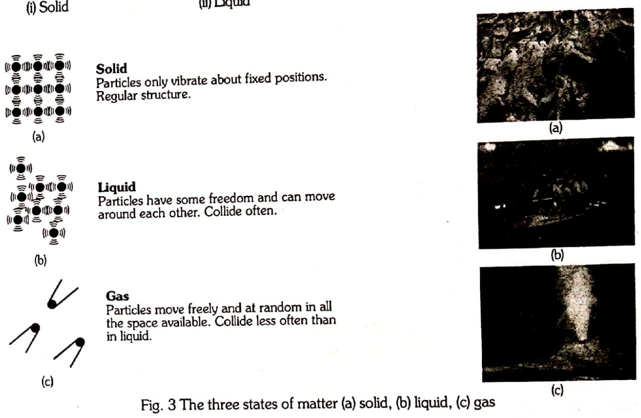

Solid
Particles only vibrate about fixed positions. Regular structure.
(a)
Liquid
Particles have some freedom and can move around each other. Collide often.
(b)
Gas
Particles move freely and at random in all the space available. Collide less often than in liquid.
(c)
(a)
(b)
(c)

Fig. 3 The three states of matter (a) solid, (b) liquid, (c) gas

These three forms are interconvertible which means they can be converted from one state of matter into another and again back to the original state.

For the interconversion to take place there has to be certain change of conditions. What are these changes of conditions ? Let us discuss.

(i) Increase or decrease in temperature.

(ii) Increase or decrease in pressure.

For example

(a) Ice, which is water in solid state, can be changed into a liquid state (water) by heating it. Above 0°C the ice gradually changes into water. On further heating the water, when the temperature reaches up to 100°C the water changes into a gaseous state called vapor or steam.

(b) When a candle, formed of wax (solid form), is lit up, it starts melting. The molten or liquid wax rises up the wick and is converted into (wax) vapor. It is this vapor which, when combined with the oxygen present in the air, burns.

(c) Similarly , gas can be changed into liquid and then into solid. This is done by cooling and/or by increasing the pressure of gas. Gases such as nitrogen, oxygen, hydrogen and helium can be converted in liquid state.

You may have heard of liquid oxygen or liquid hydrogen or solid carbon dioxide.

It is important to remember that it is not essential that all substances can be changed from one state to another. For e.g. Sugar in its solid state cannot be changed into liquid sugar because after heating, the sugar changes into a decomposed substance. This substance is not sugar.

Kinetic molecular theory of matter

It explains why solids, liquids & gases have different properties.

The word 'Kinetic' comes from the Greek word "Kinos' meaning to move.

All substances whether solids, liquids or gases, are made up of molecules, atoms or ions which are constantly moving. The physical behaviour of these substances is determined by their movement or motion.

This can be illustrated with the help of following evidence.

Movement of pollen grains in water

Pollen grains move rapidly throughout the water in a very irregular way (zig-zag way).

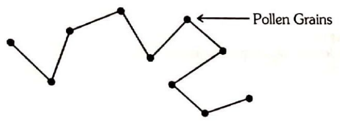


Fig. 4 Brownian motion.

The pollen grains move on the surface of water because they are constantly being hit by fast moving particles of water. This type of zig-zag movement of the small particles suspended in a liquid (or gas) is called *Brownian motion.*

Brownian motion increases the temperature because of increase in kinetic energy of particles of matter.

The existence of Brownian motion given two conclusions.

(i) Matter is made up of tiny particles. (ii) Particles of matter are constantly moving.

CONCEPTUAL CHALLENGE 1.1

Why liquids diffuse slowly as compared to gases?

Explanation

In liquids, the molecules are less free than in a gas, i.e., the intermolecular forces (vander Waals forces) in a liquid are greater than in a gas.

The theory that visualizes that any substance, whether solid, liquid or gas, is made up of atoms, molecules or ions that are in constant motion is known as the **kinetic molecular theory of matter**.

This motion may be,

(i) Translatory: The motion of particles in a particular direction.

(ii) Rotational: Motion around the axis.

(iii) Vibratory: To and fro motion of particles about the mean position.

Solids change into liquids, and liquids into gases, when the particles gain more kinetic energy, like when being heated and are able to move apart from one another. When the molecules vibrate more quickly upon heating, some of it escapes from the matter.

The main postulates of kinetic theory of matter are following:

(i) Matter consists of molecules. These are the smallest particles, which are capable of free existence and retain all the chemical properties of the parent substance.

(ii) The molecules are always in a state of random continuous motion.

(iii) The molecules exert forces on one another. These forces depend upon intermolecular distance

(iv) All collision between the particles of matter are perfectly elastic.

Molecules are always in a state of motion. In solids, they vibrate about their average positions. In liquids particles have enough free space to move about but they still attract each others. In gases particles move about randomly. Due to their motion, molecules possess kinetic energy.

Collision of particles

The particles, especially in the gaseous or liquid state, are moving in a Helter-Skelter direction. They collide with one another but these collisions are elastic. The total energy of the colliding particles remain the same. The movement is caused by the force of attraction between the molecules of a given substance. This force is known as intermolecular force. The magnitude of the force depends upon the state of the substance as well as upon the magnitude of the intermolecular spaces.

CONCEPTUAL CHALLENGE 1.2

What would have happened to the gas if the molecular collision were not elastic?

Explanation

On every collision, there would have been loss of energy. As a result, the molecules would have slowed down and ultimately settle down in the vessel. Moreover, the pressure would have gradually reduced to zero.

ACTIVITY.1.2

Let us perform an experiment which will show whether the particles are static or mobile. Take one glass test tube, place a small piece of iodine in it and cork tightly. You will find the violet vapors of iodine everywhere in the test tube. Now bring a starch iodide paper near the mouth of the test tube. The starch iodide paper becomes blue. The indicates the presence of iodine at the mouth of the test tube. The iodine particles are mobile and therefore, they move and spread in whole of the test tube.

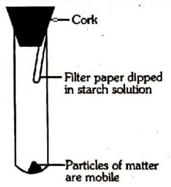

Cork
Filter paper dipped in starch solution
Particles of matter are mobile

Fig. 5 Diffusion of iodine particles.

CONCEPTUAL CHALLENGE 1.3

Salt gets dissolved in water easily even it is not externally stirred. Why?

Explanation

This can be explained on the basis of kinetic molecular theory of matter. Salt molecules and water molecules having there own K.E. when comes in contact starts mixing up on its own. It means they move that is why we get the salty taste of water from the bottom or the top of the container.

Same reason can be given to the question that "State how dust particles get mixed up in air"

1.4 States of matter on the basis of kinetic theory

The three states of matter exist and differ from one another on account of,

(i) The type of packing of their constituent particles.

(ii) Energy associated with these particles.

(iii) Inter molecular forces between them.

Characteristics of solids, liquids and gases

	Characteristics	Solids	Liquids	Gases
1	State of packing	Particles are closely packed. Their Positions are also fixed.	Particles; are loosely Packed. Their positions are not fixed.	Particles are wide apart. Their positions are not fixed.
2	Energy associated	Particles can vibrate only to and fro about their mean position. Therefore, have small energy due to their motion.	Particles can move about more freely and have considerable energy due to their motion.	Particles move about freely and have maximum energy due to their motion.
3	Intermolecular forces	Particles are held together by strong intermolecular forces. Therefore, have definite shape and volume.	Forces are strong enough to keep them within the boundaries of the liquid. The liquids do not have a definite shape but still have a definite volume.	Particles are held together by very weak intermolecular forces. Gases have neither a definite shape nor a definite volume.
4	Compressibility	Solids cannot be compressed and highly rigid.	Liquids cannot be compressed and not rigid.	Gases can be compressed and are not rigid at all.
5	Density	Solid has high density.	A liquid has comparatively high density than gases and less dense than solid.	Very less density.
6	Fluidity	Does not flow.	Liquid can flow from high level to low level	Gases can flow in any direction

Kinetic model of a solid

In a solid, for e.g., in a block of wood

(a) The molecules are closely packed. In other words the intermolecular space, which exists between the molecules, is negligible.

(b) The molecules have fixed position. That is, there is no movement.

(c) The molecules are arranged in a definite manner.

(d) There is a strong force of attraction (or intermolecular force) between them.

Types of solids

Solids are classified into two groups based on the arrangement of constituent particles.

(a) Crystalline solids (b) Amorphous solids

Crystalline solid is the one in which the constituent particles are arranged in a regular manner throughout the entire three dimensional network. A crystalline solid consists of a large number of repeating units termed as unit cells. A crystal is defined as a solid figure having planar surfaces, sharp edges and a definite geometrical shape.

Amorphous solids are those solids in which the constituent particles are arranged in haphazard manner and not in a regular fashion. These resemble liquids as they flow very slow at room temperature and thus termed as **super cooled liquids.**

The properties showing the difference between the crystalline and amorphous solids are listed in table.

Table: Difference between crystalline and amorphous solids.

	Properties	Crystalline solids	Amorphous solids
1	Crystal geometry	These have a definite crystal shape due to orderly arrangement of atoms, molecules or ions in three dimensional network.	These do not have a definite geometrical shape due to haphazard order of constituent particles.
2	M.P.	These show sharp m.p.	These do not have sharp m.p.
3	Physical state	These are hard and rigid solids.	These are comparatively soft and not very rigid.
4	Symmetry	Crystalline solids have (a) plane of symmetry (b) centre of symmetry (c) axis of symmetry.	Amorphous solids do not have any symmetry.
5	Crystal system	Crystalline solids have a definite crystal system e.g., cubic, tetragonal, hexagonal, etc.	These do not have any crystal system i.e. these do not have a regular repeating units.
6	Anisotropic or Isotropic nature	Crystalline solids show physical properties different in different directions of the crystal e.g., refractive index and electrical conductivity. So these are termed as anisotropic.	Their physical properties are same in all directions. Thus these are termed as isotropic.
7	Examples	Crystals of NaCl, CsBr, CaF_2 and ZnS.	Rubber, plastic, glass, etc.

Types of crystals

The molecules, atoms or ions are the constituent particles of crystals. Shape and appearance of the crystal depend upon the arrangement of these constituent particles. There are three types of crystals.

(i) **Covalent crystals:** The structural units for this type of crystals are atoms. Forces of attraction are comparatively weaker in these crystals. Organic compounds form such type of crystals. However, some giant molecules are also known, e.g., diamond and graphite.

(ii) **Ionic crystals:** These crystals are formed by ions. Structural unit of these crystals is ion. There exists a strong force of attraction between the particles (i.e., ions). Crystals of sodium chloride, copper sulphate, potassium chloride etc. belong to this class.

The ionic solids are usually quite hard, having high melting point. In solid state these are non-conducting but in fused or molten state these conduct electricity.

(iii) **Metallic crystals:** These crystals are formed by the atoms of metals.

(iv) **Molecular crystals:** The structural units for this type of crystal are molecule which do not carry any charge. There exists a weak force of attraction between these particles.

CONCEPTUAL CHALLENGE 1.4

Classify the following substances into ionic, covalent, molecular or metallic.

MgO, SO_2, I_2, H_2O (ice), SiO_2 (quartz), brass.

Solution

MgO = Ionic, SO_2 = Polar molecular, I_2 = non-polar, H_2O = Hydrogen bonded molecular, SiO_2 = Covalent network, brass = metallic.

Kinetic model of a liquid

In a liquid, for e.g., water or milk:

(a) The molecules lie far apart from each other.

(b) The intermolecular space is greater than that in a solid.

(c) The intermolecular force of attraction between the molecules is not strong enough to keep them binded to one position and, therefore, the molecules can move about more freely.

(d) Molecular motion is irregular and random.

Some important properties of liquids

(1) Surface tension : It is an important property of liquids, which is due to inter molecular forces of liquid particles. Liquid surface feel stretched due to surface tension.

The molecules in liquids are held closely and hence attract each other. A molecule in the bulk of the liquid is attracted equally on all sides so that the net attractive pull on the molecule is zero. However, a molecule which lies at the surface (known as surface molecule) is subjected only to the attractive forces of the molecules below it. This is because there are no molecules above it. Therefore, surface molecules experience a resultant downward attractive force within the liquid. This creates an imbalance of forces at the surface. In other words, the liquid surface is under tension due to unbalanced forces. This effect is called surface tension.

Effect of temperature

Surface tension decreases with rise in temperature. The decrease of surface tension with increase of temperature is because of the fact that the kinetic energy (or speed) of the molecules increases. As a result, the intermolecular forces decrease and therefore, surface tension also decreases. For example, the clothes are washed more efficiently in hot water than in cold water due to decreased surface tension in hot water.

Surface tension and nature of liquid

Since, surface tension of a liquid is due to intermolecular attractive forces, therefore, the magnitude of surface tension is a measure of intermolecular attractive forces. When the attractive forces between the molecules are large, the surface tension is large.

Importance of surface tension

(i) **Capillary action :** When one end of a capillary tube is put into a liquid that wets glass, the liquid rises into the capillary tube to a certain height and then stops. The rise of a liquid in capillary is called capillary action. The rise of liquid in a capillary is due to the inward pull of surface tension acting on the surface which pushes the liquid into the capillary tube. This phenomenon is very important.

For example, water below the surface of the earth rises to the plants through the roots, oil rises into the wick of an oil lamp, ink rises in a blotting paper, are examples of capillary action.

(ii) **Spherical shape of drops :** The liquid drops have nearly spherical shapes. We have learned that surface tension tries to decrease the surface area of a liquid to the minimum. Since the sphere has minimum surface area for the given volume of liquid.

(2) Viscosity: When a liquid flows through a tube, the layer of liquid in contact with the wall of the tube is stationary where as liquid in the centre has the highest velocity; intermediate layers move with a gradation of velocities. The flowing liquid may, therefore, be regarded as composed of a number of concentric tubes sliding past one another like the tubes of a telescope. Each layer exerts a drag on the next and the work must be done to maintain the flow. Similarly in a liquid flowing over a glass plate, the layer in contact with the plate remains stationary, the velocity of different layers increases continuously with the distance from the fixed surface, being the highest in the free surface of the liquid, On account of relative motion each layer experiences a frictional force and behaves as it is being dragged in backward direction. This internal friction or resistance which resists the relative motion of its own, i.e. the flow of the liquid, is known as viscosity.

Glycerine does not flow as easily as water or alcohol. Thus, glycerine is said to have more viscosity than water or alcohol.

The reason of this internal resistance (viscosity) is molecular force working between the molecules of the liquid. It depends on cohesive force between the molecules.

Viscosity and nature of liquid

The viscosity is also related to the intermolecular forces in the liquid. If the intermolecular forces are large, the viscosity will be high. For example, water has higher viscosity than methyl alcohol because intermolecular forces in water are more than in methyl alcohol.

Effect of temperature

Viscosity of a liquid decreases with rise in temperature. With the increase in temperature, the average kinetic energy increases and the intermolecular forces can be easily overcome. Therefore, the liquid starts moving faster.

Importance of viscosity

Study of viscosity helps in many ways,

(i) The shape of ships, aeroplanes, rockets etc. is designed in such a manner, so that they may have least effect on their velocity due to the friction of water, air, etc.

(ii) In order to decrease the friction in the various types of machines, suitable lubricants are selected on the basis of viscosity.

(iii) Viscosity is very helpful in determining the pressure required for sending liquids like petrol, water, etc. through pipe lines.

Kinetic model of a gas

In a gas, for e.g., nitrogen or oxygen,

(a) The molecules lie much farther apart than they do in a solid or a liquid.

(b) There is negligible force of attraction between the molecules so they are free to move within the space available to them.

(c) The molecules in a gas move much faster than in liquids and therefore possess much more kinetic energy.

(d) During this movement the molecules constantly collide with each other or with the wall of the vessel they are contained in. With every collision the direction and speed of molecules change.

(e) Because of constant collision and continuous bombardment by the molecules on the walls of the vessels, they exerts pressure.

Exertion of pressure

Solid exert pressure only in downward direction. Liquids exert pressure downward as well as to the sides. But gases exert pressure in all directions (a good example is a balloon). This pressure is due to bombardment or the particles against the walls of the container.

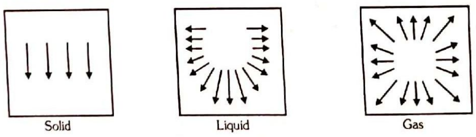


Fig. 6 Exertion of pressure.

Homogeneous nature

Gases have similar composition in all parts and are therefore homogeneous in nature.

Liquefaction

Gases can be liquefied by cooling and by applying pressure.

Diffusion

When a bottle of ammonia is opened in one corner of the laboratory, its pungent smell can be experienced all over the laboratory.

Similarly, when a bottle of perfume is opened in the drawing room its smell spreads and can be detected all over the room, In fact all gases possess this property of intermixing with one another without any mechanical aid to form a homogeneous mixture called diffusion.

Uses of gaseous diffusion

(i) **Separation of gases :** Gases can be separated from the mixture of gases by the use of process of diffusion. When a mixture of gases is diffused, the lighter gases will diffuse quickly than the heavier gases. In this way by repeating the process of diffusion, gases can be separated from the mixture.

(ii) **Relative densities and molecular weights of the gases :** Graham's Law of diffusion can be used for the determination of relative densities and molecular weights of the gases.

1.5 Interconversion of the states of matter

If the temperature of a substance is changed, its physical state also changes. When a substance changes its state it can be reverted to the original state by altering its temperature or, in case of a gas, the process can be managed by changing its pressure.

1. Melting

When the substance in solid state is subjected to heating, the molecules absorb heat energy which increases the kinetic energy of molecules. This result in increase of kinetic energy of the molecules which in turn leads to increase in temperature, further supply of heat energy does not raise the temperature of molecules. Instead, the heat energy is used up in decreasing the intermolecular forces of attraction which results in increase in intermolecular spaces. The molecular arrangement of the solid changes to that of liquid. The temperature at which a solid gets converted to liquid state at the atmospheric pressure is called melting point of the solid.

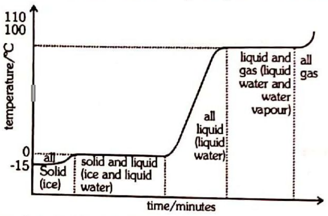


Fig. 7 Graph of temperature against time for the change from ice at –15°C to water and further to steam. Ice is solid form of water and it melt at 0°C and at 100°, it changes to vapours.

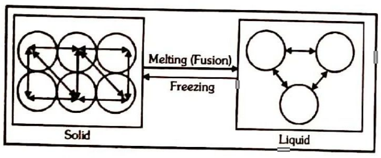


Fig. 8 Interconversion of solid and liquid state.

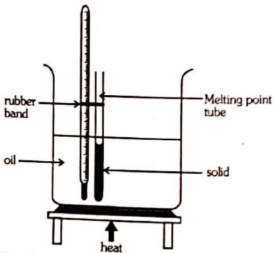


Fig. 9 Apparatus shown here to find the melting point of a substance such as the solid in the melting point tube.

ACTIVITY.1.4

Take two pieces of ice cubes and they are pressed together with application of pressure by hand. Now see on applying pressure its melting point decreases and when this pressure is released it solidifies to single piece. This principle is called **regelation.**

Different solids have different melting points.

E.g. Ice : Melting point is 0°C

Wax : Melting point is 63°C

Factors affecting melting point

(i) Effect of pressure

The effect of pressure on the melting point of solids depends upon the nature of solid. For solids which expand on melting, increase in pressure increases the melting point. This is because increase in pressure opposes expansion.

Examples : Paraffin wax, silver, gold and copper.

For solids which contract on melting, increase in pressure decreases the melting point. This is because increase in pressure favors contraction.

Examples : Ice, cast iron, brass

(ii) Effect of addition of impurities

Addition of impurities to a solid decreases the melting point of solid thereby allowing substance to melt at a lower temperature.

Example Rose's metal → Alloy of tin, lead and bismuth.

Melting point of this alloy → 94.5°C

Melting point of Pb → 327°C	Individual melting points
Melting point of Sn → 231.9°C	
Melting point of Bi → 271°C	

2. Freezing

The process of conversion of liquid state to solid state is called freezing. It is opposite to the process of melting. This is carried out by extracting heat from a liquid.

The temperature at which a liquid converts into solid at the atmospheric pressure is called freezing point of the liquid and the factors which affect the melting point of a substance obviously affect freezing point.

A mixture of 3 parts of ice and 1 part of common salt is called freezing mixture which is used to produce a lower temperature of (–21°C). Freezing mixtures are used for preservation of food especially perishables such as fish, meats and other ready to eat frozen food.

Ice a unique solid

Because it is less dense as a solid than it is as a liquid. Normally, a liquid becomes denser as it freezes and its molecules pack closer together. However, as water freezes, its molecules form a latticework of hexagons that contain empty space. These hexagons cause water to expand 11% in volume when it freezes. This expansion means that ice has fewer molecules per cubic centimeter than water has, so it is less dense than water. To be precise, ice's density is 0.917 g/cm^3 and water's maximum density is 1.00 g/cm^3 at 3.98°C.

The unique properties of ice can cause problems on land and sea. The expansion of ice is responsible of the weathering of paved surfaces, such as roads and parking lots. Ice expands in crevices in these surfaces, opening cracks that spread and eventually create potholes. While because of this ice floats on water, about 90 % of it remains below the water's surface.

3. Boiling

The process due to which a liquid changes into gaseous state by absorbing heat energy is called boiling.

Boiling point : The constant temperature at which a liquid rapidly changes into gaseous state by absorbing heat energy at atmospheric pressure is called boiling point.

Boiling point can also be defined as the temperature at which the vapor pressure of liquid becomes equal to atmospheric pressure under normal conditions.

Factors effecting boiling point

(1) Effect of pressure

The boiling point of a liquid increases with increase in external pressure. This is the reason why water boils at a lower temperature than 100°C at higher altitudes. In a pressure cooker, water is subjected to heating in a closed vessel in confined space. The steam generated in fixed volume increases the pressure beyond the normal atmospheric pressure. Hence the food is cooked earlier in a short span of time.

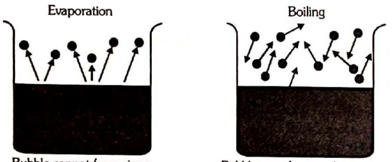
(2) Effect of impurities

When any solid substance is dissolved or added in a liquid, then the boiling point of liquid raises beyond the normal boiling point. For example, when common salt is dissolved in water, the solution boils at a temperature greater than 100°C.

Evaporation

Evaporation process is conversion of liquid state to gaseous state which can also be brought about, even without supplying heat energy to the liquid. In a liquid, the surface molecules possess higher kinetic energies than the molecules in the bulk of the liquid. Due to this reason, the molecules break away from the forces of attraction of the other molecules and go into vapor state.

So, we can say that the process of liquid changing into vapor state even below its boiling point is called evaporation.



Bubble cannot form since the vapor pressure is less than atmospheric pressure.

Bubbles can form and rise since the vapor pressure can overcome atmospheric pressure.

Fig. 10 Difference between evaporation and boiling.

Factors affecting the evaporation

(1) Temperature

The rate of evaporation increases on increasing the temperature of the liquid.

E.g. wet clothes get dry faster in summer than in winter season.

(2) Surface area

The rate of evaporation increases on increasing the surface area.

(3) Humidity of air

Humidity of air tells us the degree of dampness of air. Humidity of air lowers the rate of evaporation.

E.g. (a) In rainy season cloth needs more time to get dry than in summer season.
(b) Cereals are not getting dried in rainy seasons easily.

(4) Wind speed

The rate of evaporation of a liquid increases with increasing wind speed.

E.g. To dry the wet floor after cleaning, our maid servants put the ceiling fan on.

(5) Pressure

The rate of evaporation can also increase with a decrease in the gas pressure around a liquid. Molecules like to move from areas of higher pressure to lower pressure. The molecules are basically sucked into the surrounding area to make the pressure equal to the surrounding. If the vapor pressure of the surrounding increases to a specific level, the rate of evaporation will slow down.

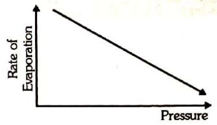


Fig. 11 Relation of rate of evaporation with pressure.

(6) Nature of liquid

Different liquids have different rates of evaporation. A liquid having weaker interparticle attractive forces evaporates at faster rate because less energy is required to overcome the attractive forces.

Example : Acetone evaporates faster than water.

4. Condensation

The conversion of gaseous substance into liquid state is called condensation. This can be carried out by cooling the gas below a particular temperature. When heat is extracted from the gas, the kinetic energy of molecules decreases and hence temperature falls leading to condensation.

The conversion of gaseous state to liquid state can also be brought about by the application of pressure. The gases have to be cooled below a certain temperature and then subjected to application of high pressure.

LPG : liquefied petroleum gas is good example of condensation of gas to liquid state.

Effects of condensation on climate

The formation of dew, fog and clouds are good examples of condensation. During day times when the temperature is high, water in water bodies evaporates and this process goes on continuously till the air does not become saturated with water vapor. When the temperature falls during night time, the air becomes saturated with water vapor. The temperature at which the atmospheric air becomes saturated with water vapor is called **dew point**.

On further lowering of temperature, some of the water vapor condenses and the water droplets condense as **dew**. If the condensation of water vapor takes place on floating dust particles, it results in the formation of **fog** or **mist**. Similarly in the upper part of atmosphere condensed water droplets appear as **clouds**.

Cooling produced due to evaporation

The liquid molecules absorb energy from the surroundings and overcome the forces of attraction thus changing into vapor state. Since surroundings lose energy, it becomes cooler. This principle is made use in various daily life activities.

(i) Cool sensation produced when alcohol is poured on palm.

(ii) Cotton clothes produce cooling effect during summer.

(iii) Formation of water droplets on the outer surface of glass containing ice cold water.

(iv) Cooling of water in earthen pots.

5. Sublimation

This is the phenomenon by which a certain substance on heating changes straight to the gaseous state without undergoing the liquid state and on cooling changes back to the solid state. This is known as sublimation.

For example, iodine, naphthalene, solid carbon dioxide (dry ice), ammonium chloride, etc., exhibit sublimation and change directly into gaseous form when heated. This can be explained with the help of the following experiment.

ACTIVITY.1.5

Aim

Heating of iodine for demonstrating sublimation

Method

Take a few crystals of iodine in a test tube. Heat them gently but take care that the upper portion of the test tube is not heated.

Observation: The shiny violet crystals of iodine directly changes into violet colored vapors, without first melting. The vapor of iodine gets deposited on the upper part of the test tube and appears as grey powder and this powder deposited on upper parts is known as sublimate.

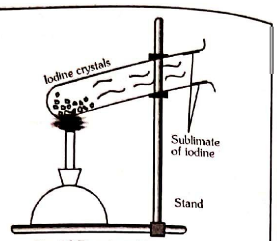


Fig. 12 Experiment to demonstrate sublimation.

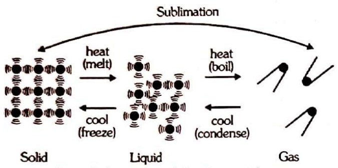


Fig. 13 Summary of the change of state.

CONCEPTUAL CHALLENGE 1.5

In woolen clothes naphthalene balls are consumed even though clothes are properly packed & not wetted. Why?

Explanation

Because naphthalene balls directly changes into vapor state without changing into liquid. Thus we observe that clothes are not wetted by use of naphthalene balls.

Difference between vapour and gas

A substance, which under ordinary conditions is a solid or a liquid, but can exist in gaseous state under specific conditions, is called vapor.

For example: Water can be water vapor under specific conditions or solid iodine, when heated, can turn into iodine vapor.

A substance, which under ordinary circumstances exists as a gas, will still remain as a gas, at room temperature and one atmospheric pressure. For example, oxygen remains oxygen, nitrogen remains nitrogen, and hydrogen remains hydrogen as gas.

Latent heat

The heat energy which has to be supplied to change the state of a substance is called its latent heat. Latent heat does not raise (or increase) the temperature. The word 'latent' means the heat which we supply is used up in overcoming the forces of attraction between particles of a substance during the change of state.

Latent heat is of two types:

(i) Latent heat of fusion, and

(ii) Latent heat of vaporization

Latent heat of fusion (Solid to liquid change)

The latent heat of fusion (or melting) of a solid is the quantity of heat in joules required to convert one kilogram of the solid (at its melting point) to liquid, without any change in temperature. For e.g. Latent heat of fusion of ice is 3.34×10^5 joules per kilogram, which is nothing but heat supplied to change 1 kg of ice (at its melting point 0℃) to water at the same temperature i.e. 0℃.

Latent Heat of vaporisation (Liquid to gas change)

The latent heat of vaporisation of a liquid is the quantity of heat in joules required to convert 1 kilogram of the liquid (at its boiling point) to vapor or gas, without any change in temperature.

The latent heat of vaporization of water is 22.5×10^5 joules per kilogram (or 22.5×10^5 J/kg).

EXERCISE

Multiple choice questions

1. The quantity of matter present in an object is called its
(1) Weight (2) Gram (3) Mass (4) Density

2. The metal which is liquid at room temperature
(1) Sulphur (2) Sodium (3) Silver (4) Mercury

3. The force that binds the particles of matter together is known as
(1) intermolecular space (2) bond
(3) intermolecular force (4) nuclear force

4. When a teaspoon of solid sugar is dissolved in a glass of liquid water, what phase or phases are present after mixing?
(1) Liquid only (2) Still solid and liquid
(3) Solid only (4) None of these

5. K.E. of molecular motion appears as
(1) Pressure (2) P.E. (3) Temperature (4) All of the above

6. Based on the statements given here choose the correct answer.
P. Some sugar can be added to a full glass of water without causing overflow.
Q. A liquid seems to be continuous even-though space is present between the molecules.
(1) P and Q are true and Q explains P (2) P and Q are true but Q does not explain P
(3) Only P is true (4) Only Q is true

7. In the solid state, the thermal agitation in the molecules is
(1) maximum (2) minimum
(3) both maximum & minimum (4) none of these

8. Which of the following properties is different for solids, liquids and gases?
(1) Movement of molecules (2) Particle size of the substance
(3) Mass of the substance (4) Energy exchanges

9. Solids usually
(1) expand large amounts when the temperature rises
(2) change shape easily
(3) have a low density
(4) none of the Above

10. Which has the least energetic molecules?
(1) Solids (2) Liquids (3) Gases (4) Plasma

11. Of gases, liquids and solids, which is the densest state of matter?
(1) Solids (2) Liquids (3) Gases (4) Plasma

12. All liquids have same
(1) density (2) viscosity (3) solubility (4) none of the above

13. Based on the statements given here choose the correct answer.
P. If we increase the temperature of a gas inside a container, its pressure also increases.
Q. Upon heating, the rate of collisions of the gas molecules increase and increases the impact of force on the walls of the container.
(1) Both P and Q are true and Q explains P (2) Both P and Q are true but Q does not explain P
(3) Only P is true (4) Only Q is true

14. According to kinetic theory of gases, molecules are
(1) perfectly inelastic particles in random motion (2) perfectly elastic particles in random motion
(3) perfectly inelastic particles at rest (4) perfectly elastic particles at rest

15. At a temperature less than critical temperature, to liquefy a gas
(1) lower the temperature, higher is the pressure required
(2) lower the temperature, lower is the pressure required
(3) higher the temperature, lower is the pressure required
(4) none of these

16. Based on the statements given here choose the correct answer.
P. Aquatic animals breathe oxygen inside water.
Q. Gases can diffuse into water.
(1) Both P and Q are true Q explains P (2) Both P and Q are true but Q does not explain P
(3) Only P is true (4) Only Q is true

17. Which of the following substance in the gaseous state may be called a vapour?
(1) Sulphur (2) CO_2 (3) Helium (4) Nitrogen

18. Which of these statement is true?
(1) Gases have high density. (2) Gases can be compressed more than solids.
(3) Gases have very specific shapes. (4) All of the Above

19. The correct statement amongst the following is
(1) gases diffuse at different rates
(2) diffusion also takes place in liquids
(3) diffusion of liquid and a gas is known as intimate mixing
(4) all are correct

20. When we put some crystals of potassium permanganate in a beaker containing water, we observe that after some time whole water has turned pink. This is due to
(1) boiling (2) melting of potassium permanganate crystals
(3) sublimation of crystals (4) diffusion

21. The boiling point of alcohol is 78°C. What is this temperature in Kelvin scale?
(1) 373 K (2) 351 K (3) 375 K (4) 78 K

22. The boiling point of water on celsius and Kelvin scale respectively is
(1) 373, 273 (2) 0, 273 (3) 273, 373 (4) 100, 373

23. Non-reacting gases have a tendency to mix with each other. This phenomenon is known as
(1) chemical reaction (2) diffusion (3) effusion (4) explosion

24. Which of these choices will not change the state of matter?
(1) Temperature (2) Crushing a crystal (3) Pressure (4) Electricity

25. What term is used to describe the phase change of a solid to a liquid?
(1) Freezing (2) Melting (3) Boiling (4) None of the above

26. What is the term used to describe the phase change as a liquid becomes a solid?
(1) Evaporation (2) Condensation (3) Freezing (4) None of the Above

27. The change of a liquid into vapour is called
(1) vaporization (2) solidification (3) sublimation (4) None of these

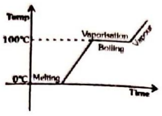
28. At higher altitudes
(1) boiling point of a liquid increases (2) boiling point of a liquid decreases
(3) no change in boiling point (4) melting point of solid increases

29. What is the term used to describe the phase change of a liquid to a gas?
(1) Boiling (2) Condensation (3) Melting (4) None of the above

30. The boiling point of a liquid.
(1) increases with pressure (2) decreases with pressure
(3) is not affected by pressure. (4) is dependent on the mass of the liquid.

31. When the vapour pressure of a liquid is equal to its atmospheric pressure, then it
(1) freezes (2) evaporates (3) boils (4) does not undergo any change

32. In an experiment of conversion of ice into water and water into vapour, observations were recorded and a graph plotted for temperature against time as shown below. From the graph it can be concluded that



(1) ice takes time to heat up to 0°C
(2) during melting and boiling temperature does not rise
(3) process of boiling takes longer time than the process of melting
(4) all of the above

33. In which phenomenon water changes into water vapour below its B.P.?
(1) Evaporation (2) Condensation
(3) Boiling (4) No such phenomena exist

34. The process of evaporation causes
(1) heating (2) cooling
(3) increase in temperature (4) none of these

35. The liquid which has the highest rate of evaporation is
(1) petrol (2) nail-polish remover (3) water (4) alcohol

36. If you leave water in a glass and some molecules turn into a gas, it is called
(1) Egasoration (2) Evaporation (3) Extinction (4) Solidification

37. Water cycle is an example of which of the following ?
(1) Change in the composition of matter.
(2) Effect of pressure on the melting point of a solid.
(3) Inter conversion of state of matter.
(4) Effect of pressure on the boiling point of matter.

38. When water particles condenses on dust particles in air, it forms
(1) mist (2) cloud (3) frost (4) vapour

39. Match the following and choose the correct answer.

a. Evaporation	i. Liquid to gas at a fixed temperature
b. Vaporisation	ii. Solid to gas
c. Sublimation	iii. Gas to solid
d. Hoar frost	iv. Liquid into gas at any temperature

(1) a-iv, b-i, c-ii, d-iii (2) a-i, b-ii, c-iii, d-iv (3) a-ii, b-iii, c-iv, d-i (4) a-iv, b-i, c-iii, d-ii

40. The solid state of CO_2 is called
(1) tear gas (2) cooking gas (3) dry ice (4) laughing gas

41. The substance that exist in solid state and change to vapours on heating
(1) Napthalene balls (2) Dry ice (3) Iodine (4) All of the above

42. Which of the following substances can sublime?
(1) Camphor (2) Solid carbon dioxide (3) Ammonium chloride (4) All

43. Which is more effective in cooling?
(1) Water at 0°C (2) Water at 100°C (3) Ice at 0°C (4) All of these

44. Latent heat of fusion for ice is
(1) 80 gm cal^{-1} (2) 80 cal/gm (3) 19 J cal^{-1} (4) None of these

45. Match the following and choose the correct answer.

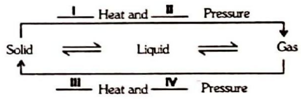
a Solid	i. Super energetic particles
b Liquid	ii. No shape nor fixed volume at a given pressure
c Gas	iii. Has definite shape
d Plasma	iv. Definite volume with less molecular forces than that in solids.

(1) a-i, b-ii, c-iii, d-iv (2) a-iii, b-iv, c-ii, d-i (3) a-iii, b-iv, c-i, d-ii (4) a-i, b-iv, c-ii, d-iii

46. How many classical states of matter are there?
(1) Two (2) Three (3) Four (4) Five

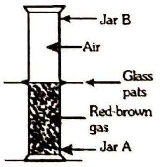
47. The state of matter which consists of super energetic particles in the form of ionized gases is called
(1) gaseous state (2) liquid state
(3) Bose-Einstein condensate (4) plasma state

48. What are I, II, III and IV ?



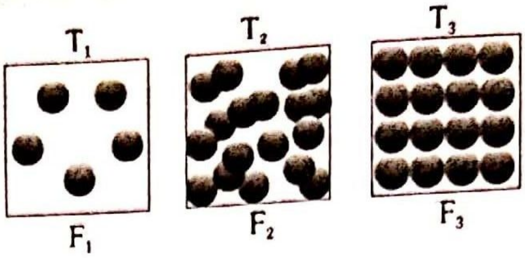
	I	II	III	IV
(1)	Increase	Increase	Decrease	Decrease
(2)	Decrease	Decrease	Increase	Increase
(3)	Increase	Decrease	Decrease	Increase
(4)	Decrease	Increase	Decrease	Increase

49. If we remove the glass plate, the process taking place is



(1) condensation (2) sublimation (3) diffusion (4) evaporation

50. The microscopic view of three different substances are shown in the given diagram. Where T_1, T_2 and T_3 are temperatures and F_1, F_2 and F_3 are the forces of attraction of the particles of the respective states. Choose the correct order among the following.



(1) $T_1 < T_2 < T_3$ and $F_1 < F_2 < F_3$

(2) $T_1 > T_2 > T_3$ and $F_1 > F_2 > F_3$

(3) $T_1 < T_2 < T_3$ and $F_1 > F_2 > F_3$

(4) $T_1 > T_2 > T_3$ and $F_1 < F_2 < F_3$

ANSWERS

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	3	4	3	1	3	1	2	1	4	1	1	4	1	2	1	1	1	2	4	4
Que.	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Ans.	2	4	2	2	2	3	1	2	1	1	3	4	1	2	2	2	3	1	1	3
Que.	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**										
Ans.	4	4	3	2	2	2	4	3	3	4										